AD NUMBER

AD514877

CLASSIFICATION CHANGES

TO: unclassified

FROM: confidential

LIMITATION CHANGES

TO:

Approved for public release, distribution unlimited

FROM:

Controlling Office: Naval Weapons Center, China Lake, CA.

AUTHORITY

OCA; Apr 1983 IAW document markings; USNWC Notice 4 Jan 1984

NWC TP 5128
COPY 8

AD514872

FAST-BURNING RATE/HIGH SLOPE PROPELLANT TECHNOLOGY PROGRAM

THIRD QUARTERLY PROGRESS REPORT
1 NOVEMBER 1970–31 JANUARY 1971
(U)

by
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for the
Propulsion Development Department

ABSTRACT. (U) This is the third quarterly program report on work conducted to advance state-of-the-art with regard to formulation of practical fast-burning and high pressure-exponent propellants. Primary emphasis was directed toward optimization of the processing, mechanical, and ballistic properties.

(U) This quarter's effort was directed at final tailoring of propellant formulations using functionally modified R-45M polymer. Incorporation of HAA into the formulation containing catocene resulted in an increased pot life. Formulations were scaled up to 10-pound-batch size, and 2-inch-diameter motors were cast. Two grains of each formulation were static fired. Physical properties, safety data, and limited aging data were obtained on the formulations.

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FOREWORD

This third quarterly report describes progress during the period 1 November 1970 through 31 January 1971 on Navy Contract N00123-70-C-1457 to Aerojet General Corporation, Sacramento, California. This work is sponsored by the Naval Weapons Center (NWC), China Lake, Calif., and supported by the Naval Air Systems Command under AirTask A3303300/216B/IF 19332302.

F. M. Pickett of NWC is the technical coordinator and has reviewed this report for technical accuracy.

Released by
R. A. MILLER, *Head*
Propulsion Systems Division
15 March 1971

Under authority of
G. W. LEONARD, *Head*
Propulsion Development Department

NWC Technical Publication 5128

Published by .... Propulsion Development Department
Collation .... Cover, 13 leaves, DD Form 1473, abstract cards
First printing .... 260 numbered copies
Security classification .... CONFIDENTIAL
Abstract alone .... UNCLASSIFIED
Title alone .... UNCLASSIFIED

CONTENTS

INTRODUCTION

(U) This is the third quarterly progress report presented to the U. S. Navy, Naval Weapons Center, China Lake, California, for work conducted under contract N00123-70-C-1457 for the period 1 November 1970 through 31 January 1971. A glossary of terms and abbreviations is provided.

OBJECTIVE

(U) The objective of this 10-month program is to advance the state-of-the-art with regard to formulation of practical fast-burning and high pressure-exponent propellants by expanding available technology.

(U) The research performed will provide the capability to formulate two propellants, hereinafter referred to as "A" and "B", with respective burning rates of 3.5 and 7.0 in./sec at 2000 psia and a pressure exponent for both propellants of about 0.70.

(U) Both propellants will be formulated to deliver a specific impulse (I^{15}_{1000}) of at least 240 lbf-sec/lbm with a density of 0.063-0.065 lbs/in.^{3}. The study also includes the development of adequate mechanical properties to withstand the temperature range of -40 to 160°F. Other considerations are adequate processing, potlife (4 hrs. @ 135°F), thermal and aging stability and safety characteristics. Only composite propellants are being considered, with porous AP (PAP) and non-volatile ferrocene derivatives limited to the high burning rate propellant "B".

SUMMARY

(U) Candidate formulations using modified R-45-M were established for both propellants "A" and "B", and were designated, respectively, ANB-3394 and ANB-3395. Several 10-lb batches of each formulation were prepared to check processing, safety, mechanical and ballistic properties as well as to cast 2" x 6.25" grains for delivery to NWC, China Lake. Representative grains from each formulation were test fired to check burning rates. Nozzle deposition produced erratic pressure-time traces, so H-60 aluminum was substituted for H-95 aluminum in subsequent batches to improve combustion efficiency. Additional small grains were prepared from each formulation to ensure sufficient void-free grains for delivery. The incorporation of HAA into ANB-3395 was found to significantly increase its potlife, and was, therefore, made a permanent part of the formulation having the designation ANB-3395-1. I.C.C. tests on both propellants established them as Class "B" explosives.

(U) Final tailoring and selection of candidate formulations for propellants "A" and "B" involved the use of functionally modified R-45-M. A substantial increase in potlife was realized for propellant "A", but "B" did not show any significant improvement due, possibly, to a cure catalytic effect of catocene. The addition of 2,4-pentanedione (HAA) to the propellant "B" formulation, however, resulted in a potlife comparable to that of "A".

(U) Final ballistic modification of propellant "B" yielded a candidate formulation having acceptable processing characteristics, while achieving the desired burning rate at 2000 psia, and propellant "A" was evaluated at two lower plasticizer levels. Initial viscosities were too high, however, to seriously consider this route in spite of mechanical property improvements.

(U) Twenty-eight phenolic sleeves, 2.05" x 7.00" long, were lined with modified 434-4 liner. Half of them were cast with ANB-3394 ("A") propellant and the rest with ANB-3395 ("B").

(U) Viscosity build-up measurements of ANB-3394 ("A") were measured at 110°F, 120°F, and 135°F, and 120°F appeared to give the best compromise between viscosity and potlife.

(U) Mechanical properties and solid strand burning rates were measured on all the 10-lb batches. Generally good agreement of both properties was observed within each three batch set for "A" and "B". The solid strand burning rates at 2000 psia were within 3 and 8% of the desired goals for "A" and "B", respectively. Two grains from each formulation were test fired to substantiate solid strand burning rates. Erratic pressure-time traces due to nozzle deposition were observed, however, the burning rates corresponding to the average motor pressures agreed well with the solid strand rates.

(U) All the cured grains were X-rayed. Of the twenty-eight grains cast only five grains containing ANB-3394 and six grains containing ANB-3395 propellant appeared to be void free. The remaining grains had voids primarily within one inch of the top. Additional small grains were prepared using both candidate formulations in which H-95 aluminum was replaced with H-60 aluminum to improve combustion and minimize nozzle deposition. X-rays revealed all but one grain of ANB-3395-1 to be void free, whereas only two void free grains were observed for ANB-3394. Additional grains were prepared with ANB-3394 and are being X-rayed.

(U) Safety data were obtained on both propellants in both the uncured and cured state. No unusual handling or processing hazards were indicated. In addition, I.C.C. tests on both candidate formulations indicated them to be Class "B" explosives.

(U) DPT molds were prepared with each candidate formulation using the modified 434-4 liner. Bonds were good with failure occurring

within the propellant.

(U) A propellant "A" formulation was checked for mechanical properties after aging at 135°F for three months. A small loss in elongation was noted.

TECHNICAL DISCUSSION

(U) Candidate formulations for propellants "A" and "B" were selected during this report period in accordance with the protracted program schedule. These formulations were arrived at after final binder tailoring of propellant "A" was completed and ballistic solids adjustment of propellant "B" was concluded. Hazard tests were run on the "B" formulation both in the uncured and cured state to determine if this propellant posed any unusual hazard during the mixing operation or while handling after cured. Additionally, the effect of three months storage at 135°F on the mechanical properties of a propellant "A" formulation was measured. 10-lb batches of each candidate were prepared to provide sufficient propellant to cast small motor grains for testing and delivery to NWC, China Lake. In addition, suitable samples were cast to evaluate viscosity build-up, safety characteristics of the uncured propellants, and mechanical, ballistic and bonding properties.

Processing and Mechanical Properties Tailoring

(U) Tailoring of propellant "A" was directed at further optimization of modified R-45-M for the best combination of processing and mechanical properties. The modification designated R-45M-35 appears to give a satisfactory combination of tensile and elongation (Table 1, AK7591-81) while providing a potlife of about three hours at 120°F. This potlife is about two and one-half times that achieved for unmodified R-45-M, as was shown in the previous Quarterly report. The formulation selected as the candidate for propellant "A" is shown in Table 2 and represents the best combination of processing, mechanical and ballistic properties. This formulation is being used to prepare and deliver the propellant grains as specified by the contractual requirements.

(U) Due to the processing improvements that have been made in propellant "A", lower plasticizer levels were evaluated to see if mechanical properties could be improved while maintaining adequate processability (Table 1, AK7591-83, -85). Unfortunately, only increases in tensile were achieved, elongation remaining constant. This improvement in mechanical properties was not sufficient to seriously consider using lower plasticizer levels in light of the increases in viscosity that result. A comparison of viscosity buildup vs time under a shear stress of 10,000 dynes/cm^2 at 120°F is presented in Figure 1 for three plasticizer levels. The potlife, measured as time to 50,000 poise, falls off rapidly as plasticizer decreases. Primarily, this is a result of starting at progressively higher viscosities, since the rates of viscosity

(C) TABLE 1. Ballistic and Mechanical Properties Propellants "A" and "B"

Batch # AK7591-	Formulation Type	Formulation Variables: AP(10μ) %	Formulation Variables: Oronite 6 %	Formulation Variables: Catocene %	Mech. Prop. @ 77°F: σ_m, psi	Mech. Prop. @ 77°F: ϵ_m, %	Mech. Prop. @ 77°F: E_o, psi	r_{2000} in/sec	n	Shore "A"
79	A	--	4.5	--	109	15.4	770	3.37	0.73	62
81[a]	A	--	4.5	--	86.5	19.1	540	3.40	0.77	45
83[a]	A	--	3.5	--	93.8	18.7	605	3.45	0.77	53
85[a]	A	--	2.5	--	116	19.1	735	3.54	0.74	60
87	B	17.0	1.0	3.5	149	16.1	1074	6.98	0.86	70
89[b]	B	21.0	0.5	4.0	115	16.7	781	6.78	0.80	67

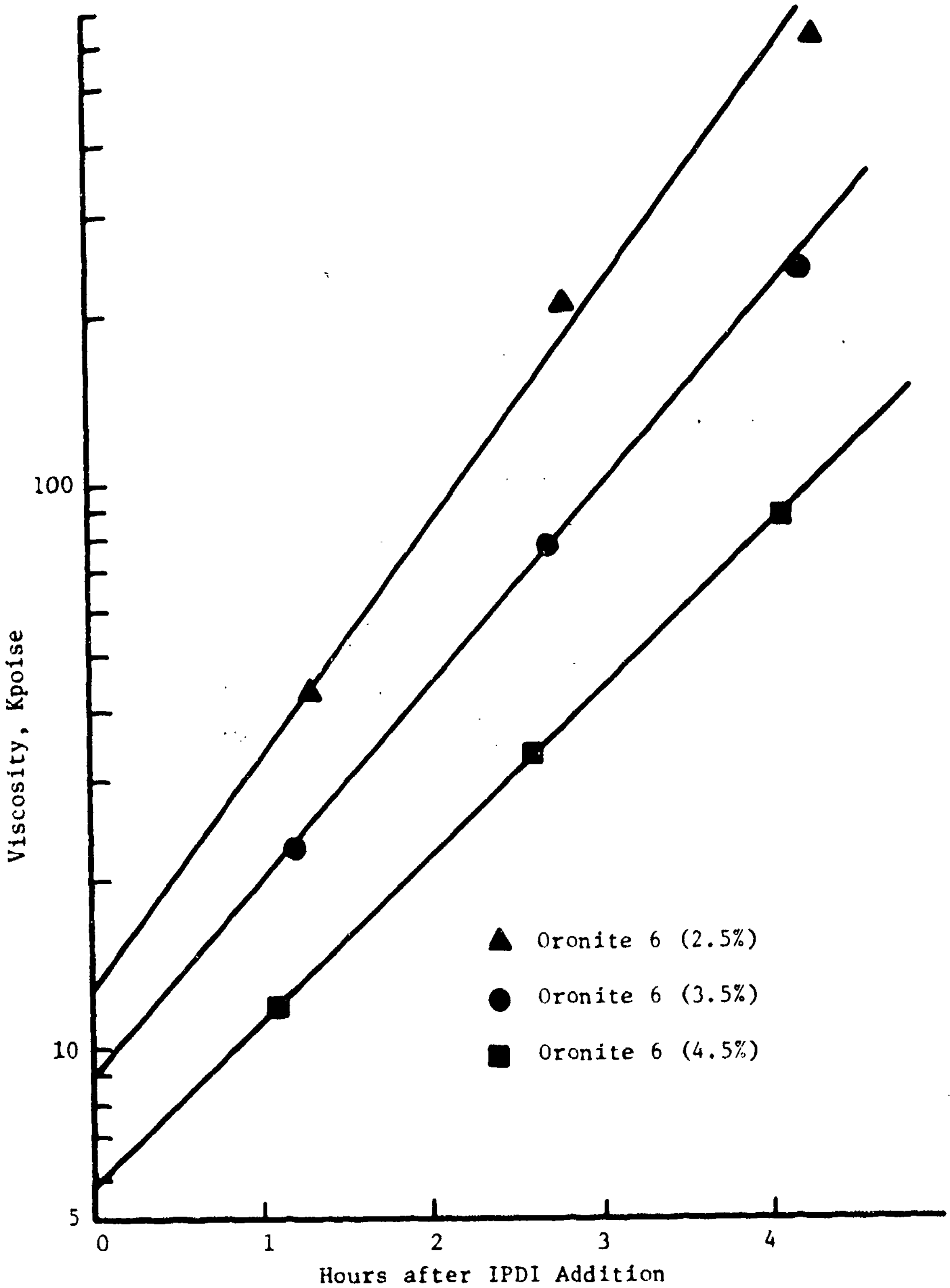
NOTE: All "A" formulations contain 45% AP (0.55μ), 14% AP (5μ), 15% Al-H95, 0.5% Fe_2O_3, 0.5% Silon S, and 15% HTPBD binder. The "B" formulations contain 62% fine AP, 8% PAP (unground), 15% Al-H95 Catocene as shown and remainder HTPBD binder.

[a] Contains R-45M-35, all other batches containing R-45M-25.

[b] Contains 40% AP (0.5μ), all other batches containing 45% AP (0.5μ).

(C) TABLE 2. Candidate Formulations, Propellants "A" and "B".

Designation	A(ANB-3394)	B(ANB-3395-1)
Ingredients	wt. %	wt. %
NH_4ClO_4 (0.5μ)	45.00	42.00
NH_4ClO_4 (5μ)	24.00	--
NH_4ClO_4 (10μ)	--	20.00
NH_4ClO_4 (Porous, 180μ)	--	8.00
Al-H60	15.00	15.00
Catocene	--	4.00
Fe_2O_3 (crystalline)	0.50	--
Silon S	0.50	--
Agerite White	0.20	0.20
Plastinox #711	0.30	0.30
HAA	--	0.20
Oronite 6	4.50	0.30
R-45M-35 (78 eq.)	9.08	9.08
DEO (15 eq.)	0.21	0.21
TEA (7 eq.)	0.02	0.02
IPDI (100 eq.)	0.69	0.69
	100.00	100.00



(U) FIG. 1. Effect of Oronite 6 Level on Propellant "A" Viscosity vs. Time at 10,000 dynes/cm^2 Shear Stress and 120°F.

buildup are similar. Going to higher cast temperatures would lower these initial viscosities, but owing to rapid buildup rates, the useful potlife would be severely shortened.

(U) In finalizing propellant "B", the best levels of catalyst and UFAP were considered. A higher catalyst level allows the desired burning rate to be achieved at a lower 0.5μ UFAP level (Table 1, AK7591-89). Such a composition gives a lower initial viscosity and longer potlife but may yield a more hazardous propellant. However, tests on both uncured and cured samples of these propellants showed them to have comparable safety characteristics as shown on page 19. ' though the formulation with 45% 0.5μ UFAP and 3.5% catocene essentially meets the required burning rate, the candidate "B" formulation (Table 2) was selected with the 4% catocene level in order to get by with a lower UFAP level allowing improved processability.

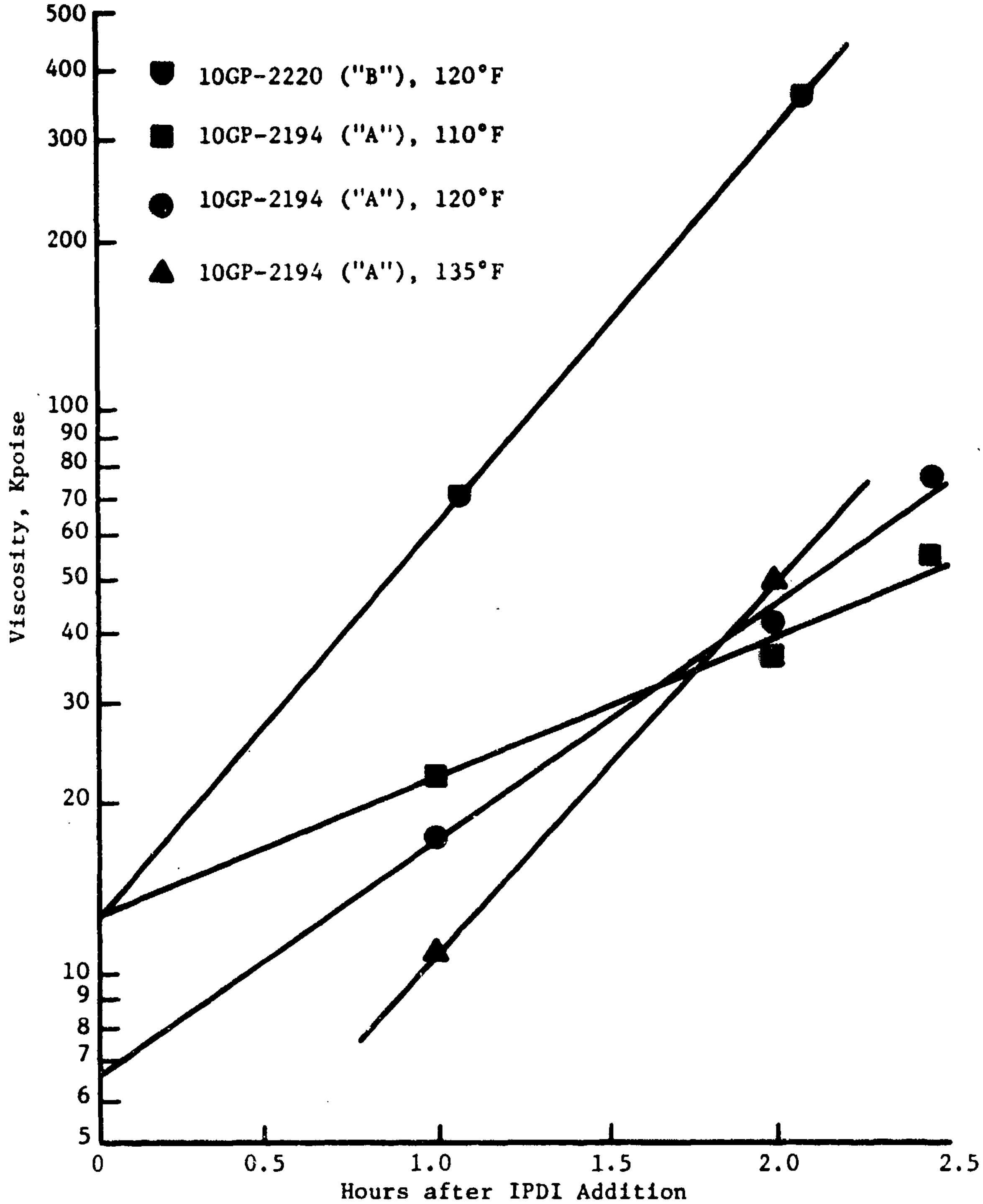
Propellant Scale-Up and Grain Preparations

(U) The candidate formulations for propellants "A" and "B" designated ANB-3394 and -3395, respectively, were scaled-up to the 10-lb batch size. Three such batches of each candidate formulation were required to provide sufficient propellant to cast 28 phenolic sleeves, 2.05" I.D. x 7.00" long. These sleeves were lined wtih modified 434-4 liner and precured for 1.5 hours at 75°C prior to casting with propellant. The liner was modified to lower its viscosity for easier application. This was accomplished by lowering the Sb_2O_3, P-33 and Refracil levels.

(U) Both candidate propellants processed without difficulty, however, "A" had noticeably better castability than "B". Viscosity buildup data (Figure 2) indicate that propellant "B" has less useful pot life than propellant "A". This is due both to a higher initial viscosity and a faster cure rate for "B". The higher initial viscosity undoubtedly is a result of replacing Oronite 6 with the more viscous catocene. The faster cure rate appears to be caused by the catocene functioning as a cure catalyst.

(U) In general, mechanical properties agreed well within each three batch set (Table 3). Propellant "A", however, showed some cure variability which was reflected in the mechanical property measurements. Both propellants "A" and "B" showed little variation in elongation when measured over the temperature range of 160°F to -40°F. Final mechanical property measurements will be made with the specified JANNAF specimens instead of the minibone specimens used to date to conserve propellant.

(U) All the grains and the various test samples cast were cured for nine days at 135°F. Cures were good for both propellants. All the cured grains were X-rayed. Only five propellant "A" grains and six propellant "B" grains appeared free of defects. Since a minimum of 10 good grains of each candidate formulation are needed for delivery to



(U) FIG. 2. Viscosity Buildup of Candidates "A" (110°F, 120°F, and 135°F) and "B" (120°F), at 10,000 dynes/cm^2 Shear Stress.

(U) TABLE 3. Mechanical and Ballistic Properties of ANB-3394 ("A") and ANB-3395 ("B")

Batch No. 10GP-	Mechanical Properties					Ballistic Properties, 80°F				
	Shore "A"	Temp., °F	σ_m, psi	ϵ_m, %	E_o, psi	r_{500} in/sec	r_{1000} in/sec	r_{1500} in/sec	r_{2000} in/sec	n
2194[a]	28	77	68.2	25.1	337	1.21	2.06	--	3.43	0.75
2212[a]	31	77	59.7	17.9	395	1.20	2.04	--	3.45	0.76
2213[a]	40	77	78.2	18.5	488	1.20	2.02	2.74	3.40	0.74
2213	--	160	47.2	14.0	358	--	--	--	--	--
2213	--	0	150.3	19.4	1029	--	--	--	--	--
2213	--	-40	327.1	17.7	2419	--	--	--	--	--
2220[b]	48	77	84.1	17.5	609	2.19	3.58	--	6.50	0.86[c]
2228[b]	47	77	76.7	15.3	586	2.27	3.55	--	6.60	0.88[c]
2248[b]	48	77	85.6	16.8	637	2.17	3.54	5.15	6.70	0.90[c]
2248	--	160	61.7	16.4	433	--	--	--	--	--
2248	--	0	197.7	16.9	1535	--	--	--	--	--
2248	--	-40	445.2	14.0	4192	--	--	--	--	--

[a] Candidate "A" propellant.
[b] Candidate "B" propellant.
[c] Measured in pressure range 1000 - 2000 psi.

NWC according to the work statement, additional batches of each candidate were prepared to cast more grains. Casting procedures were modified to assure a higher yield of good grains. The modifications included: (1) overcast additional 1-inch, (2) cast vibration and (3) small stream casting.

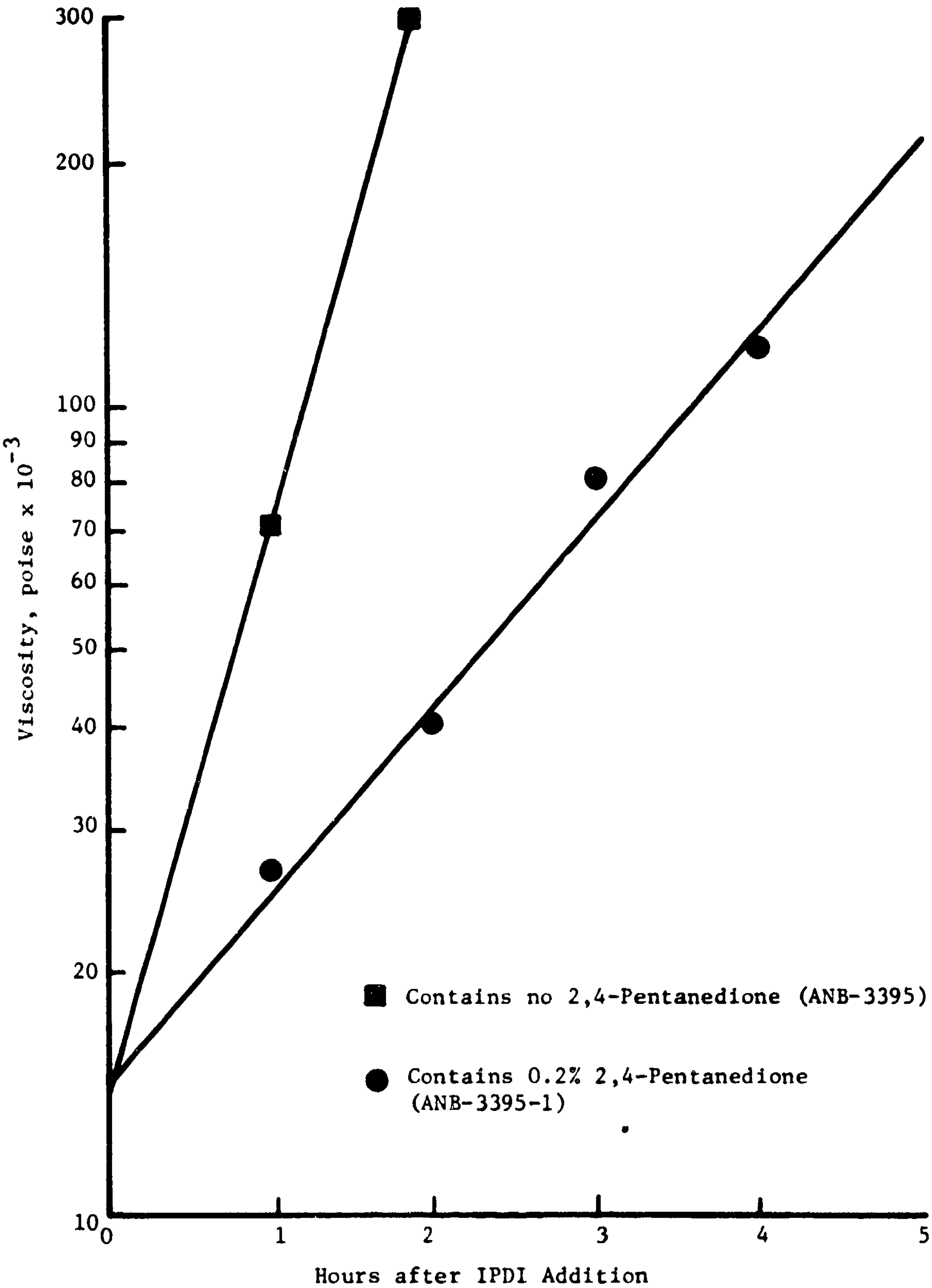
(U) As mentioned above, the short potlife of propellant "B" is probably due in large part to a cure catalytic effect of the catocene. Assuming the catalytic species to be an Fe^{+++} catocene compound, 2,4-pentanedione (HAA) was added to chelate this Fe^{+++} species and suppress ionization to the free catalytic Fe^{++} compound. This resulted in a significant increase in potlife (Figure 3). This potlife compares favorably to that of ANB-3394 (Figure 2). The HAA (0.2% of formulation) modified formulation ANB-3395-1 will replace ANB-3395 in further work on this contract.

(U) The switch to Al H-60 (see next section) to improve aluminum combustion efficiency had little effect on the processing and casting properties of both propellants. Using Al H-60, twelve grains each of ANB-3394 and -3395-1 were prepared. X-rays revealed all but one of the ANB-3395-1 grains to be void free, and all but two of the ANB-3394 grains contained fissures. The difference in grain integrity is believed to be caused by insufficient vibration during the casting of ANB-3394. Additional grains have been made with ANB-3394 and are in the process of being X-rayed. The ANB-3395 grains are being processed for shipment to NWC, China Lake. The 5-in. by 15-in. grains are expected to be ready for delivery in March.

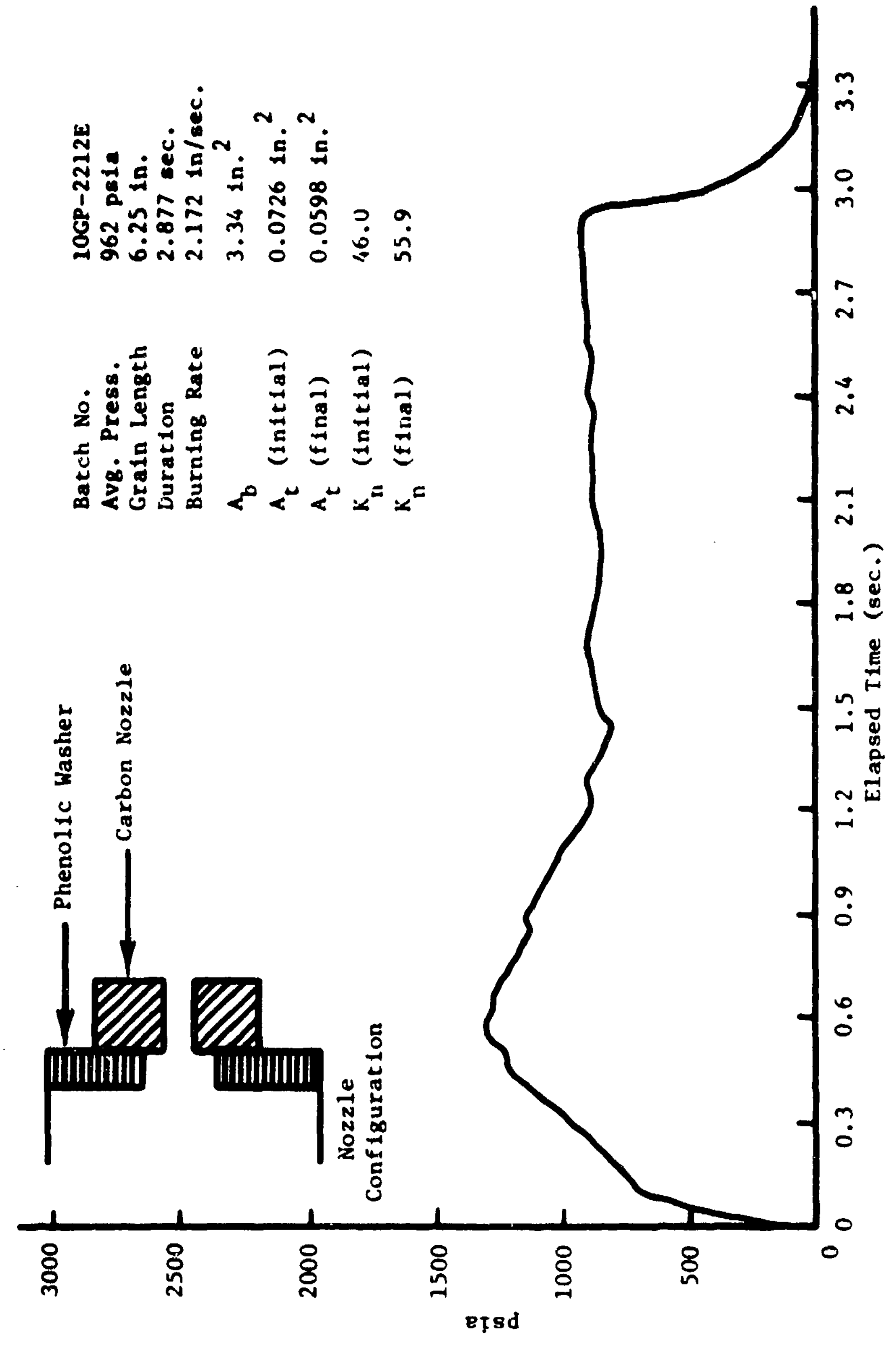
Ballistic Properties of ANB-3394 and -3395

(U) Two end burning grains each of ANB-3394 and -3395 were test fired. Erratic pressure-time traces were observed (Figures 4, 5, 6 and 7) which resulted from deposition of condensable combustion products on the nozzles and periodic removal of these deposits by gas flows. The first two motor firings (Figures 4 and 5) were made with non-contoured carbon nozzles. The second two firings (Figures 6 and 7) were made with contoured boron nitride nozzles to improve gas flow and minimize deposition. The average pressures were calculated from the pressure-time traces and the resulting burning rates matched closely the solid strand rates from the same propellants (Figure 8).

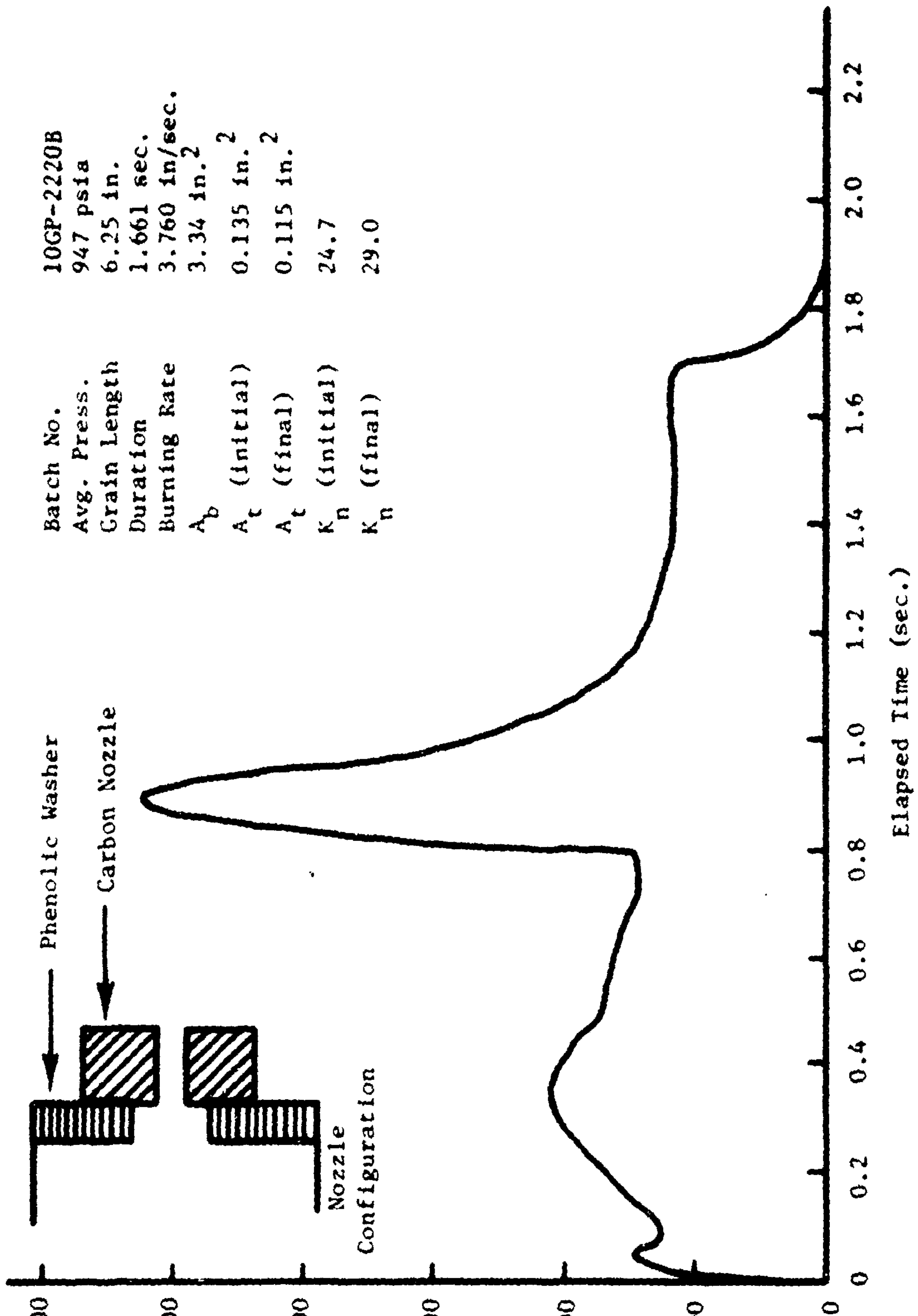
(U) As can be seen from the pressure-time traces, going to contoured boron nitride nozzles showed some improvement but did not adequately solve the deposition problem. It appears that the coarse H-95 aluminum is not completely burned in the initial phase of the firing, which in combination with a low motor L* and an unfavorable aft-closure design, causes deposition of condensable species in the exhaust. The shape of the p-t trace and level of the equilibrium pressure of these firings indicate that grain integrity is not a contributing factor to the



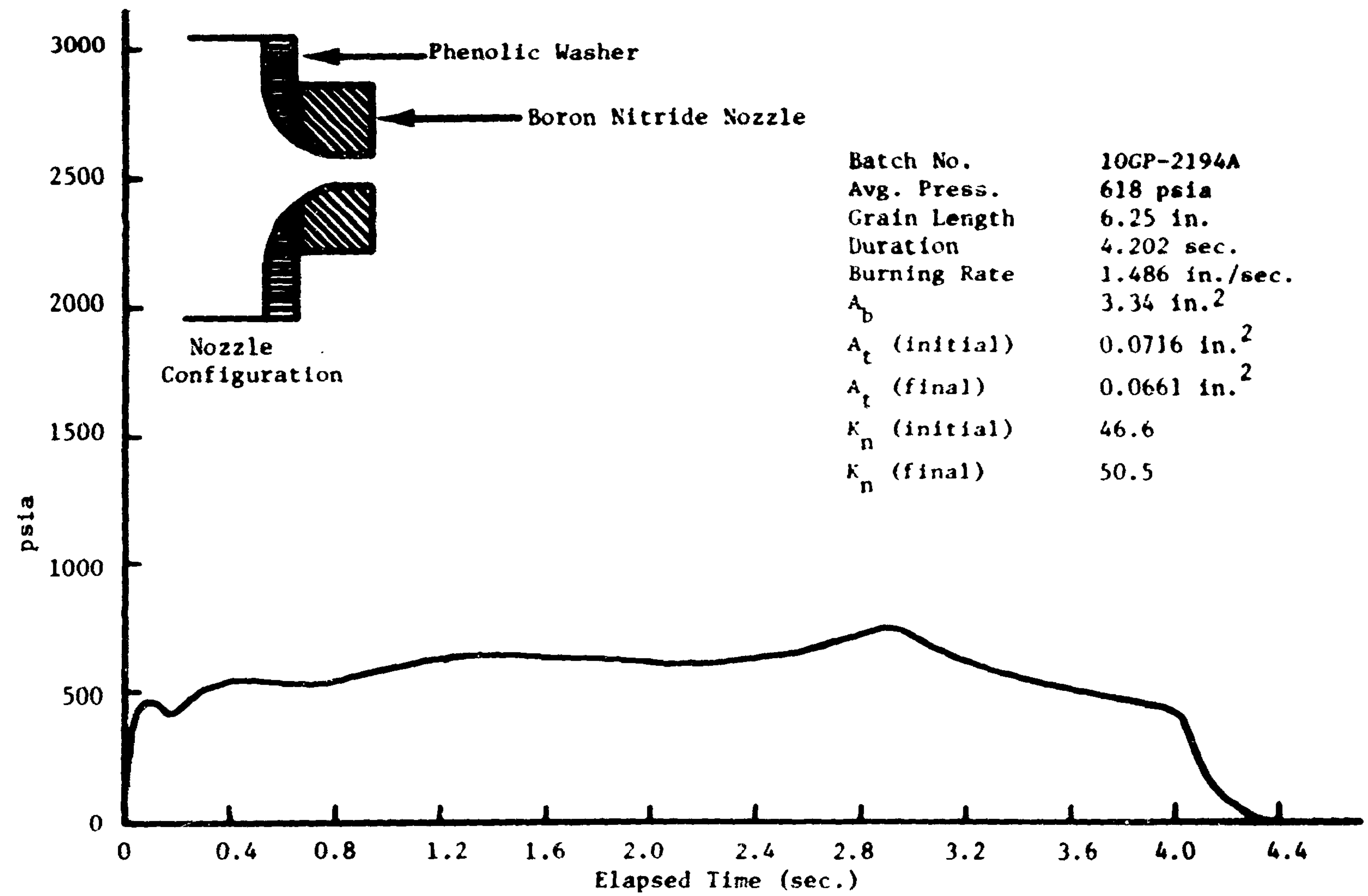
(U) FIG. 3. Viscosity Build-up of ANB-3395 (B) at 120°F and 10,000 dynes/cm^2 Shear Stress with and without 2,4-Pentanedione.



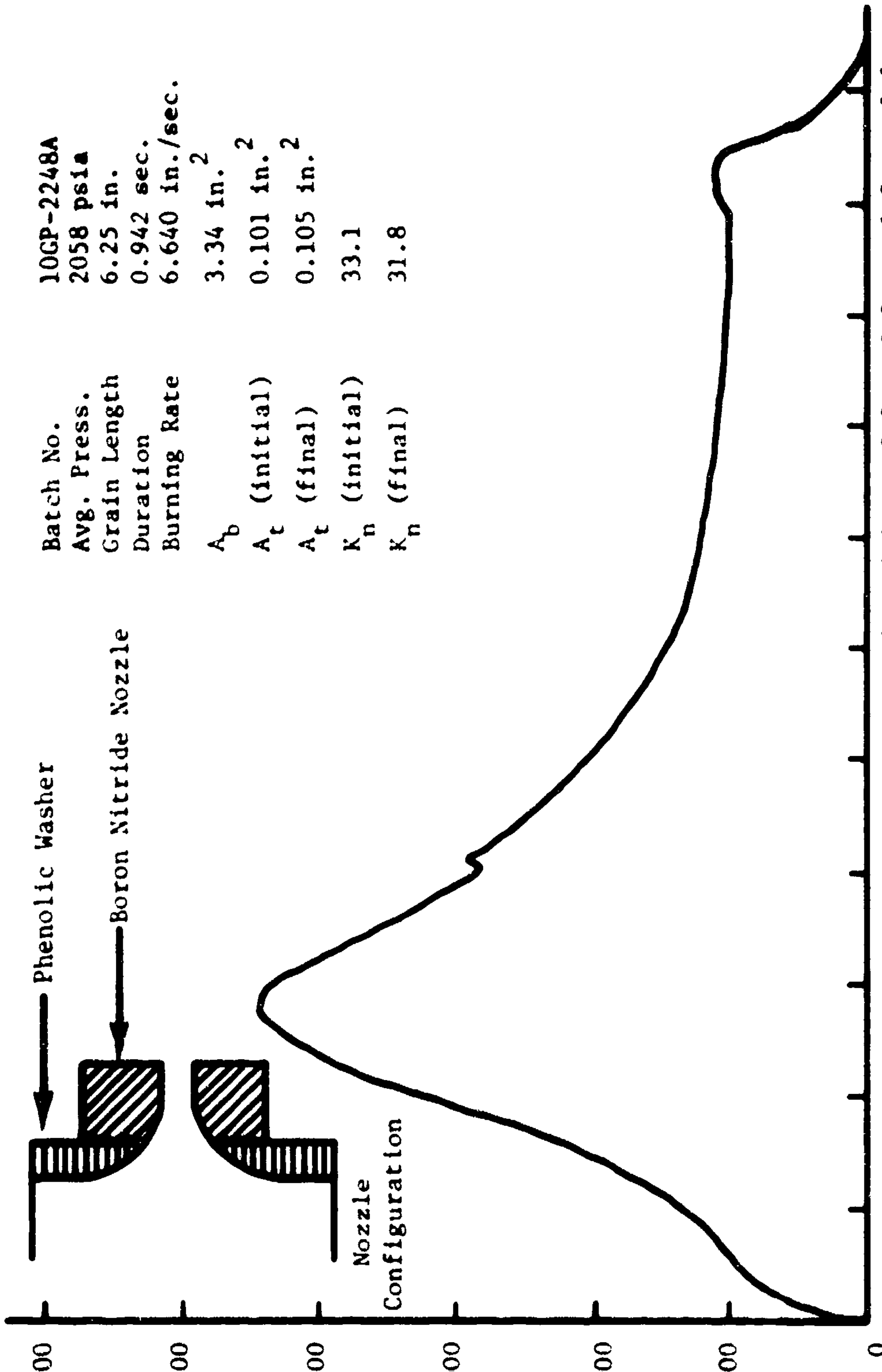
(U) FIG. 4. Pressure-Time Trace of ANB-3394 (A) Motor Firing Using a Non-Contoured Carbon Nozzle



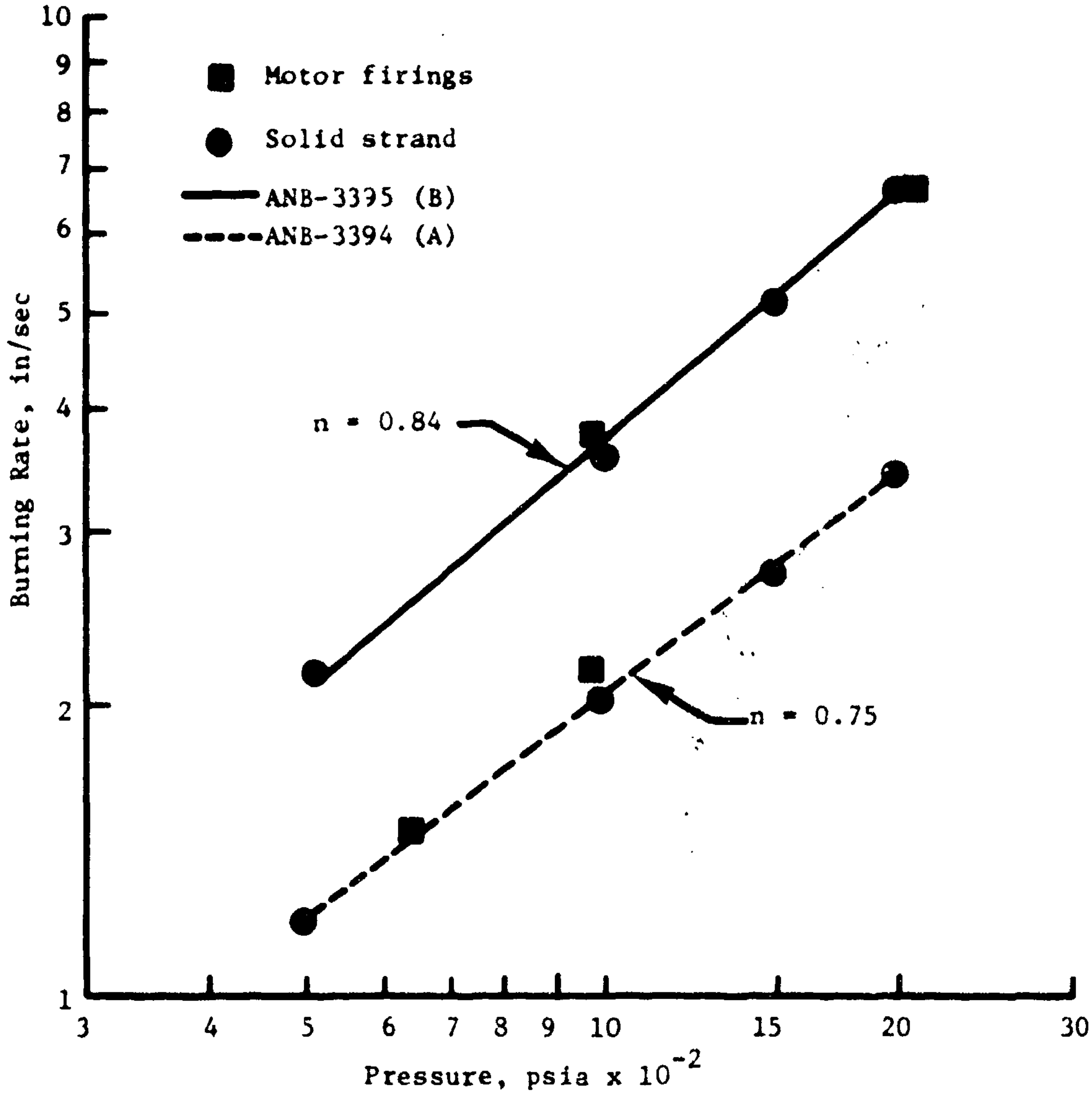
(U) FIG. 5. Pressure-Time Trace of ANB-3395 (B) Motor Firings Using a Non-Contoured Carbon Nozzle



(U) FIG. 6. Pressure-Time Trace of ANB-3394 (A) Motor Firing Using a Contoured Boron Nitride Nozzle.



(U) FIG. 7. Pressure-Time Trace of ANB-3395 (B) Motor Firing Using a Contoured Boron Nitride Nozzle.



(U) FIG. 8. Solid Strand and Motor Burning Rate Curves for ANB-3394 (A) and ANB-3395 (B) Propellant Formulations.

pressure irregularities. The problem of low L* and consequently low residence time is frequently encountered when high r propellant is test fired in motors designed for low r propellants. A greater L* (ratio of free chamber volume to throat area) would probably alleviate this problem, but, unlike I.D. burning grains, this would create more wall surface on which unburned aluminum could condense and deposit. A more favorable aft-closure contour such as those used for ducted rocket propellants would probably be helpful.

(U) The agreement in solid strand burning rates within each three 10-lb batch set was good. The measured solid strand rates at 2000 psi were slightly lower than desired (Table 3), however, they are only 3 and 8% below the targets for propellants "A" and "B", respectively, and it appears that the motor rates are equaling or exceeding target burning rates.

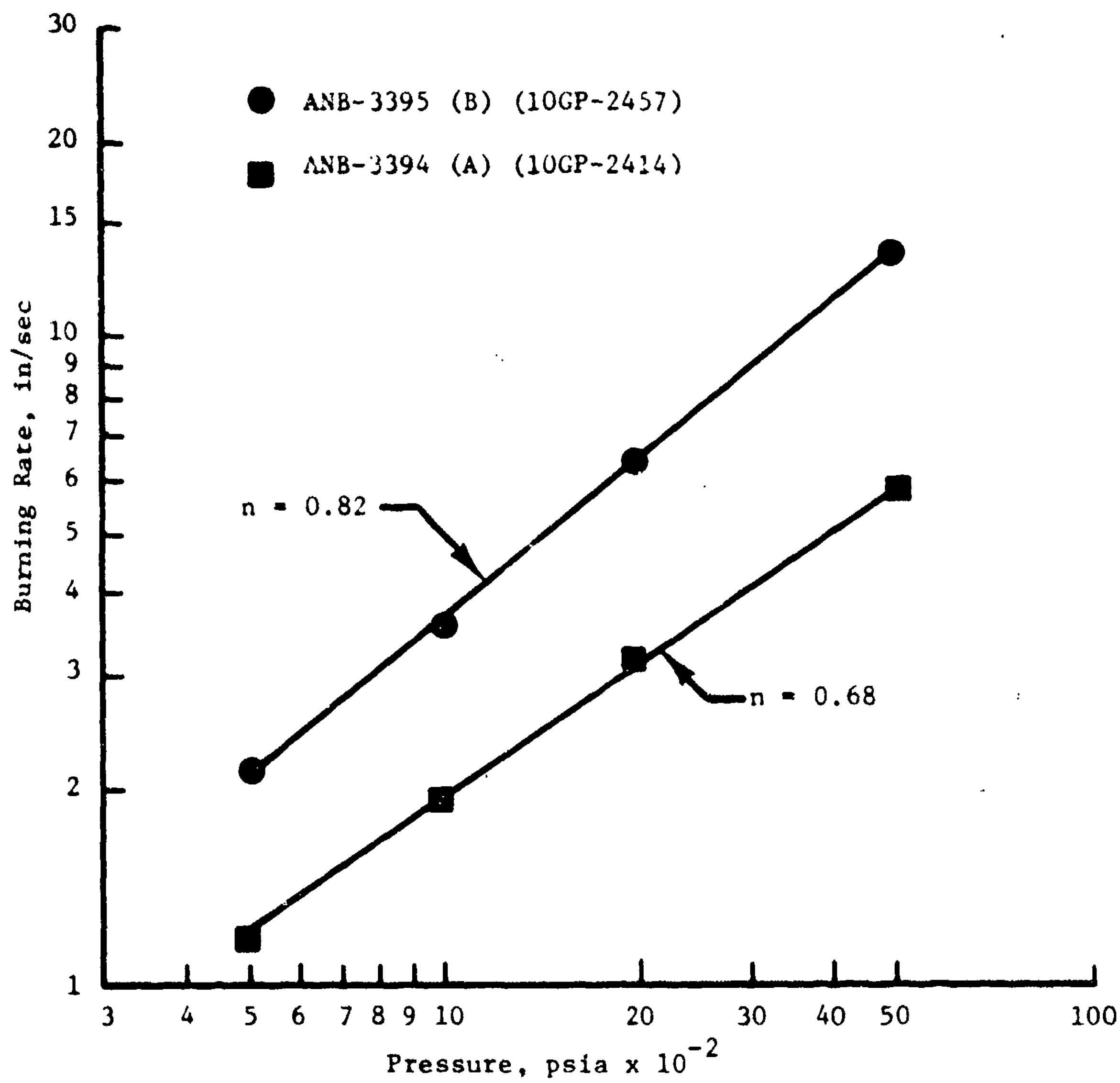
(U) The 0.9 burning rate pressure exponent between 1000 and 2000 psi for propellant "B" is higher than desired. It may be lowered by removing some of the PAP. This would also lower the burning rate at 2000 psi. It may be noted that propellants with 0.9-0.95 exponent are routinely fired on the Spartan Controllable Rocket Motor Program without difficulty.

(U) Subsequent batches were prepared with H-60 aluminum replacing the coarser H-95 aluminum. This was expected to improve the combustion efficiency of the aluminum and thereby reduce deposition. To increase L*, firings will be made using 3-in. grains. Also, about 1/4 to 1/2-in. of a non-aluminized propellant will be cast on top of these grains that will serve to preheat the chamber prior to ignition of the candidate propellants. A sharp pressure increase will mark the ignition of the fast-burning propellants.

(U) Solid strand burning rates for ANB-3394 and -3395-1 were measured to 5000 psia (Figure 9). The slopes for both propellants were essentially unchanging over the entire pressure range of 500-5000 psia. ANB-3394 was a little lower in solid strand burning rate at 2000 psia than expected, and is probably due to a new lot of the 5μ uncoated UFAP used which is greater than 5μ average particle size. This is being checked.

Safety Tests on Candidate Propellants "A" and "B"

(U) In selecting the final composition for propellant "B", due consideration was given to the hazard characteristics of the two compositions from which the candidate formulation was selected. The desired composition from the standpoint of processing, AK7591-89, contained 42% 0.5μ UFAP and 4% catocene, while the other composition, AK7591-87, which gave essentially the same burning rate, contained 45% 0.5μ UFAP and 3.5% catocene and it was feared that the higher catocene level of the former would give a less safe propellant. The data shown below,



(U) FIG. 9. Solid Strand Burning Rate Curves for ANB-3394 (A) and ANB-3395 (B) Candidate Formulations Containing H-60 Aluminum.

however, indicated little or no differences between the two, allowing the desired choice to be made based on processability. In addition, hazard tests were run on the uncured propellants to see if any special processing or handling techniques were required. The data indicated both uncured propellants were quite safe to handle in ordinary fashion.

HAZARD TESTS ON PROPELLANT "B"
UNCURED AND CURED

Safety Data	Batch AK7591-87 Cured	Batch AK7591-87 Uncured	Batch AK7591-89 Cured	Batch AK7591-89 Uncured
Bureau of Mines Impact, cm/2Kg	10.0	18.7	11.4	19.2
Friction Rotary, gms/rpm	2300/3000	3000/5200	2200/3000	3000/4700
DTA				
Onset pt., °F	329	--	309	--
Exothermic Peak, °F	395	--	389	--
Ignition, °F,	444	--	432	--

(U) Both candidate formulations from 10-lb batches were again checked for impact and friction sensitivity in the uncured state to determine possible differences in hazard properties due to scale-up. None were evident from the data.

SAFETY TESTS ON BOTH UNCURED
CANDIDATE PROPELLANTS

	ANB-3394 (10GP-2194)	ANB-3395 (10GP-2220)
Bureau of Mines Impact, cm/2Kgm wt	26	14.4
Rotary Friction, gm load/ 3000 RPM	2420	3200

(U) I.C.C. hazard classification tests were run on ANB-3394 and -3395 as outlined in TB-700-2. The results (Table 4) show both propellants to be Class "B" explosives.

(U) All safety tests have been completed except the electrostatic discharge test. This will be completed by the end of the next monthly report period.

(U) TABLE 4. Safety Data, NWC Candidate Propellants

	Candidates	
	A (ANB-3394)	B (ANB-3395)
1. Bureau of Mines Impact 50% pt., cm/2 Kg. wt.	17.0	13.5
2. DTA Results		
Onset of Exotherm, °F	335	328
Exotherm Peaks, °F	435	385
Ignition, °F	451	428
3. Copper Block		
Autoignition, °F	433	368
4. Thermal Stability at 75°C for 48 hr.	No change	No change
5. Detonability with No. 8 Blasting Cap	Burned in 8 sec.	Burned in 4 sec.
6. Unconfined Burning for 2 in. cube	9 sec.	4 sec.
7. Friction Rotary, 50% point	1750 gm. load 3000 rpm	1700 gm. load, 3000 rpm

Propellant "A" Aging Results

(U) Preliminary aging effects on mechanical properties were measured for an 86% solids propellant "A" formulation (see First Quarterly report, Table 4) after three months storage at 135°F. The data, shown below, indicate a lowering of elongation had taken place with little change in tensile strength.

THREE MONTH STORAGE AT 135°F OF 86% SOLIDS
PROPELLANT "A" FORMULATION

	Storage Temp., °F	
	75°F	135°F
77°F Mechanical Properties		
σ_m, psi	109	100
ε_m, %	18.5	13.9
E_o, psi	679	785

Bonding to Modified 434-4 Liner

(U) DPT molds were prepared with each candidate propellant using modified 434-4 liner. Previous tests had shown 434-4 liner to give good bonds to these propellants. The modified 434-4 liner also gave good bonds to these propellants as shown below.

DPT VALUES FOR CANDIDATE PROPELLANTS USING
MODIFIED 434-4 LINER AT 74.6°F

	ANB-3394 (10GP-2213)	ANB-3395 (10GP-2248)
Tensile, psi	68.9	94.9
Type of Failure	In Propellant	In Propellant

Glossary of Terms and Abbreviations

Agerite White	Antioxidant
AO-2246	Antioxidant
AP	Ammonium Perchlorate
BDB	Aerojet proprietary coating agent
BRA-99	Aerojet proprietary combustion catalyst
BRA-101	Aerojet proprietary combustion catalyst
CTPB	Carboxy terminated polybutadiene
DEO	Hydroxy functional wetting agent
DOA	Dioctyladipate
EDB	Aerojet proprietary fuel component
ERL-4205	Bis(2-3-epoxycyclopentyl)ether
ERL-4221	3,4-Epoxycyclohexylmethyl-(3,4-epoxy) cyclohexane carboxylate
FC-155	Aerojet proprietary fuel component
Freon-113	1,1,2 Trifluoro-1,2,2 Trifluoro-1,2,2 Trichloroethane
HC-434	Carboxy terminated polybutadiene (Thiokol Chemical Co.)
HDI	Hexamethylene diisocyanate
HTPB	Hydroxy terminated polybutadiene
Hycat-6	A non-volatile liquid ferrocene derivative
IDP	Isodecyl pelargonate plasticizer
IPDI	Isophorone diisocyanate
Isonol	Phosphorous containing polyol
MA	Mikro-atomizer ground ammonium perchlorate
MSA	Mine Safety Appliances Co., particle size measuring apparatus, a liquid sedimentation technique
nBF	n-Butylferrocene
P-33	Thermal carbon black
PAP	Porous Ammonium Perchlorate
Plastinox 711	Antioxidant
R-45-M	Free radical initiated HTPB
Refrasil	Silica Fiber
SS-AP	Slow-speed mikro-pulverized ground ammonium perchlorate

Glossary of Terms and Abbreviations (cont'd)

SURFAC OS	Carboxy functional wetting agent
TEA	Triethanol amine
TEHOS	2-Ethylhexylorthosilicate
Thixcin E	Modified 1-hydroxy stearin
UFAP	Ultra-fine ammonium perchlorate ($<5\mu$)
VEM	Vibro-energy mill

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FAST-BURNING RATE/HIGH SLOPE PROPELLANT TECHNOLOGY PROGRAM
Third Quarterly Progress Report 1 November 1970 - 31 January 1971 (U)

Third Quarterly Progress Report 1 November 1970 - 31 January 1971

R. L. Lou and A. Katsakian, Aerojet General Corporation

April 1971	24	0

N00123-70-C-1457 AirTask A3303300/216B/IF 19332302	NWC TP 5128
	1600-Q-3

	Naval Weapons Center China Lake, California 93555

(U) This is the third quarterly progress report on work conducted to advance state-of-the-art with regard to formulation of practical fast-burning and high pressure-exponent propellants. Primary emphasis was directed toward optimization of the processing, mechanical, and ballistic properties.

(U) This quarter's effort was directed at final tailoring of propellant formulations using functionally modified R-45M polymer. Incorporation of HAA into the formulation containing catocene resulted in an increased pot life. Formulations were scaled up to 10-pound-batch size, and 2-inch-diameter motors were cast. Two grains of each formulation were static fired. Physical properties, safety data, and limited againg data were obtained on the formulations.

DD FORM 1 NOV 65 1473 (PAGE 1)
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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Solid Propellant						
HTPB						
Ultrafine AP						
Porous AP						
High Burning Rate						
High Slope						
Ferrocene						

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ABSTRACT CARD

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